

Exploration Medical Capability (ExMC) Science and Research: Overview and Update

National Aeronautics and
Space Administration



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Advance **medical system design** and **risk-informed decision-making** for **exploration** beyond low Earth orbit to promote human health and performance in space

Risk of Adverse Health Outcomes & Decrements in Performance due to Medical Conditions that occur In Mission

Ineffective/ Toxic Medications During Long-Duration Exploration Spaceflight

DRM Categories	Mission Type and Duration	Operations		Long-Term Health	
		LxC	Risk Disposition *	LxC	Risk Disposition *
Low Earth Orbit	Short (<30 days)	3x2	Accepted	3x2	Accepted
	Long (30 days-1 year)	4x2	Accepted	4x2	Accepted
Lunar Orbital	Short (<30 days)	4x2	Accepted	3x2	Accepted
	Long (30 days-1 year)	5x3	Requires Mitigation	4x2	Requires Characterization
Lunar Orbital + Surface	Short (<30 days)	4x3	Requires Characterization	4x2	Requires Characterization
	Long (30 days-1 year)	5x4	Requires Mitigation	4x4	Requires Characterization
Mars	Preparatory (<1 year)	5x4	Requires Mitigation	4x4	Requires Characterization
	Mars Planetary (730-1224 days)	5x5	Requires Mitigation	5x4	Requires Characterization

DRM Categories	Mission Type and Duration	Operations		Long-Term Health	
		LxC	Risk Disposition *	LxC	Risk Disposition *
Low Earth Orbit	Short (<30 days)	1x1	Accepted	1x1	Accepted
	Long (30 days-1 year)	1x1	Accepted	1x1	Accepted
Lunar Orbital	Short (<30 days)	2x1	Accepted	1x1	Accepted
	Long (30 days-1 year)	3x2	Accepted with Optimization	2x2	Accepted with Monitoring
Lunar Orbital + Surface	Short (<30 days)	3x1	Accepted with Optimization	2x1	Accepted with Monitoring
	Long (30 days-1 year)	4x2	Accepted with Optimization	2x2	Accepted with Monitoring
Mars	Preparatory (<1 year)	4x3	Requires Characterization	3x2	Accepted with Monitoring
	Mars Planetary (730-1224 days)	5x3	Requires Mitigation	5x3	Requires Mitigation

Human Research Roadmap



Risk of Adverse Health and Performance Effects of Celestial Dust Exposure

DRM Categories	Mission Type and Duration	Operations		Long-Term Health	
		LxC	Risk Disposition *	LxC	Risk Disposition *
Low Earth Orbit	Short (<30 days)	Not Applicable	Not Applicable	Not Applicable	Not Applicable
	Long (30 days-1 year)	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Lunar Orbital	Short (<30 days)	1x2	Accepted	1x2	Accepted
	Long (30 days-1 year)	1x2	Accepted	1x2	Accepted
Lunar Orbital + Surface	Short (<30 days)	2x2	Accepted	2x3	Requires Mitigation
	Long (30 days-1 year)	3x3	Requires Mitigation	3x4	Requires Mitigation
Mars	Preparatory (<1 year)	Not Applicable	Not Applicable	Not Applicable	Not Applicable
	Mars Planetary (730-1224 days)	4x4	Requires Characterization	4x4	Requires Characterization

Risk of Renal Stone Formation

DRM Categories	Mission Type and Duration	Operations		Long-Term Health	
		LxC	Risk Disposition *	LxC	Risk Disposition *
Low Earth Orbit	Short (<30 days)	1x4	Accepted with Monitoring	1x3	Accepted with Monitoring
	Long (30 days-1 year)	3x4	Accepted with Monitoring	2x3	Accepted with Monitoring
Lunar Orbital	Short (<30 days)	1x4	Accepted with Monitoring	1x3	Accepted with Monitoring
	Long (30 days-1 year)	3x4	Accepted with Monitoring	2x3	Accepted with Monitoring
Lunar Orbital + Surface	Short (<30 days)	1x4	Accepted with Monitoring	1x3	Accepted with Monitoring
	Long (30 days-1 year)	3x4	Accepted with Monitoring	2x3	Accepted with Monitoring
Mars	Preparatory (<1 year)	3x4	Requires Mitigation	3x4	Requires Mitigation
	Mars Planetary (730-1224 days)	4x4	Requires Mitigation	4x4	Requires Mitigation

Human Research Roadmap



- Clinical research (e.g., pharm)
- Scientific publications
- Clinical evidence for trade space tools

**Scientific &
Clinical
Research**

**Technology
Demonstrations**

**Systems
Engineering**

- Concepts of Operations
- Requirements development
- Model-based Systems Engineering
- Trade space analysis

- Diagnostic and treatment technologies for exploration missions
- Medical Autonomy

ACCOMPLISHMENTS – 2022

CURRENT AND FUTURE EFFORTS – 2023 AND BEYOND

Medical System Foundation for Level of Care IV: Long Duration Lunar Orbit and Lunar Surface

Medical System Content

A Medical System Foundation is a system model that contains both Systems Engineering products and Clinical Data. It is meant to serve as a starting point for NASA programs that are developing mission- and vehicle- specific medical systems. New users of this web report are recommended to reference the accompanying context, process and history document while viewing the report: [Medical System Foundation for LoC IV LDLOLS Context Process and Project History \(Not available outside of NASA\)](#)

The Medical System is a subsystem of the Crew Health and Performance (CHP) system; it interfaces with the other CHP subsystems and vehicle systems external to the CHP system. The Medical System Foundation model captures systems engineering and clinical content and the relationships that exist between and among them. The model includes a Concept of Operations (ConOps), a list of functions traceable to the ConOps content, requirements derived from the functions, a set of medical conditions that could occur in-flight, medical capabilities, and example resources that could be used to diagnose or treat these conditions.

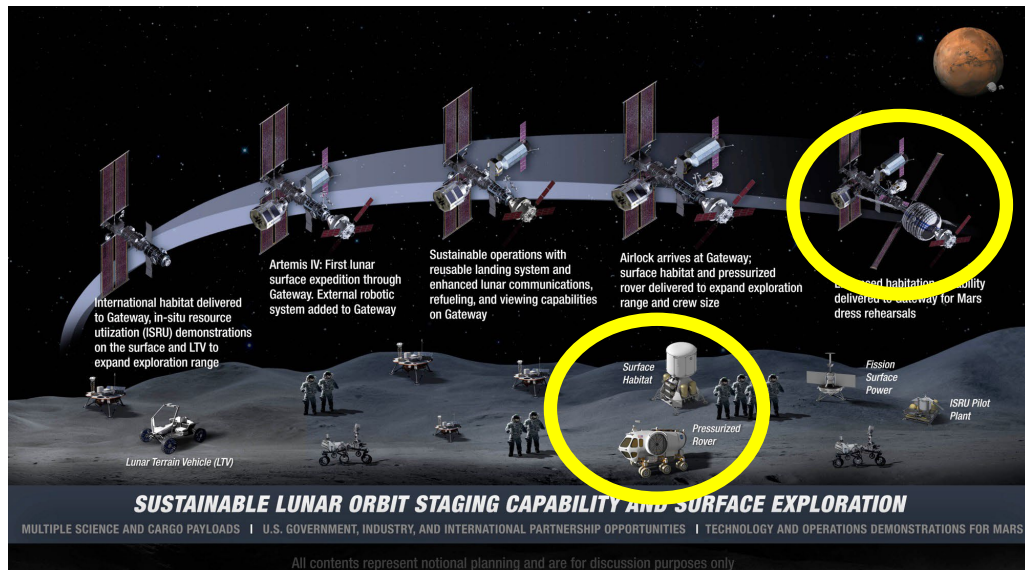
Information about the Medical System Foundation



- Developed a Medical System Foundation for Extended/Sustaining Artemis missions and Mars Transit Hab

1. Concept of Operations
2. Medical condition, clinical capability, and resource sets
3. System Model with Requirements and traces

- Intended to be a starting point (a “Foundation”) for early medical system design to build from and that can be tailored for specific missions
- Coming soon to ExMC public website with:
 - Short training videos
 - Readable in standard web browser

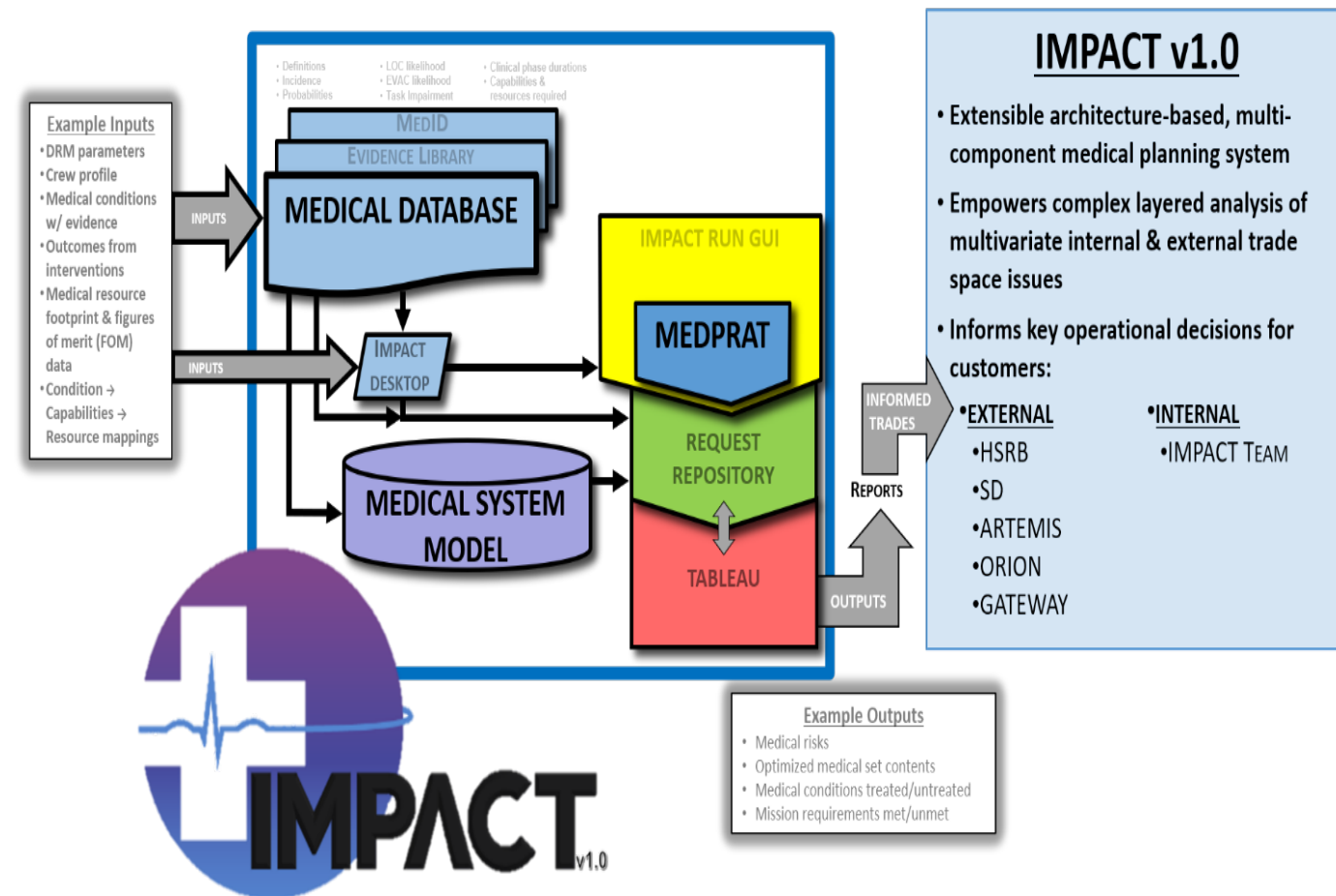




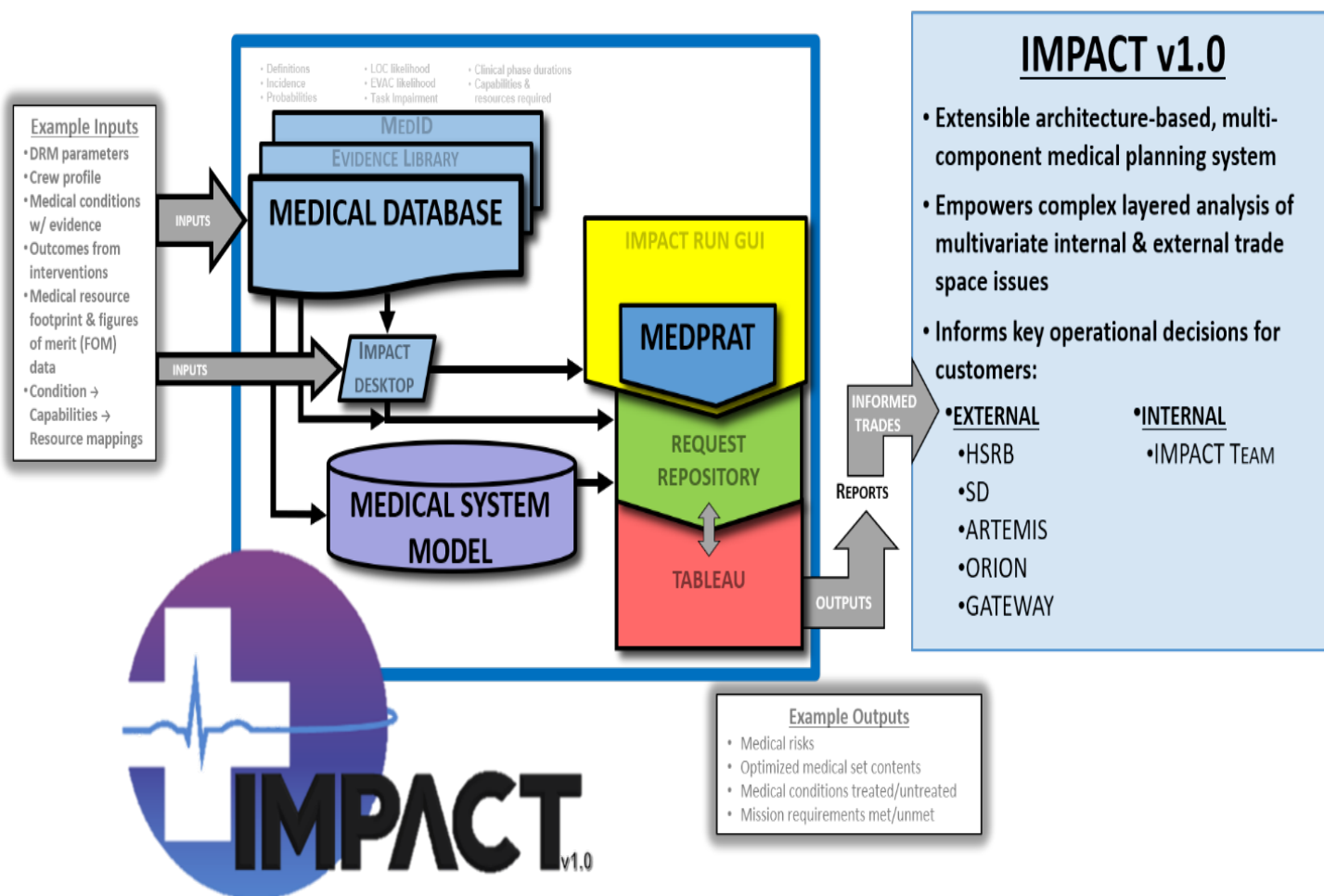
- Aspirational title
- Progressive transfer of autonomy and decision-making for exploration missions
- FY23- Define Vision and Concept of Operations
- FY24+
 - Medical Training
 - Decision Support
 - Medical Ops with comm latency
 - Requirements

IMPACT = Informing Mission Planning via Analysis of Complex Tradespaces

- Probabilistic Risk Assessment (PRA) model and Tradespace analysis tool suite
- Expanded to 120 medical conditions, ~700 clinical resources
- Baselined to lunar missions
- Successor to IMM
- Now “pencils down” and completing verification, validation, and credibility (VV+C)



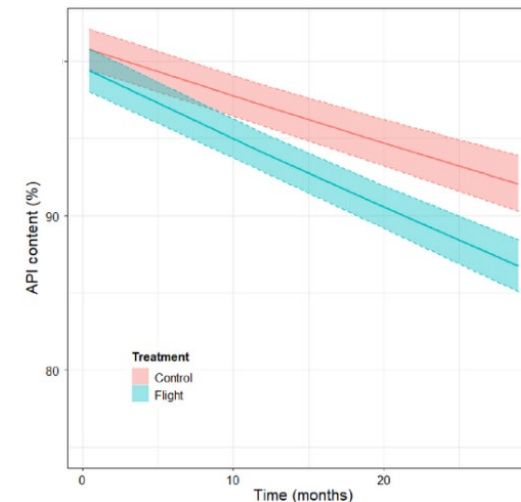
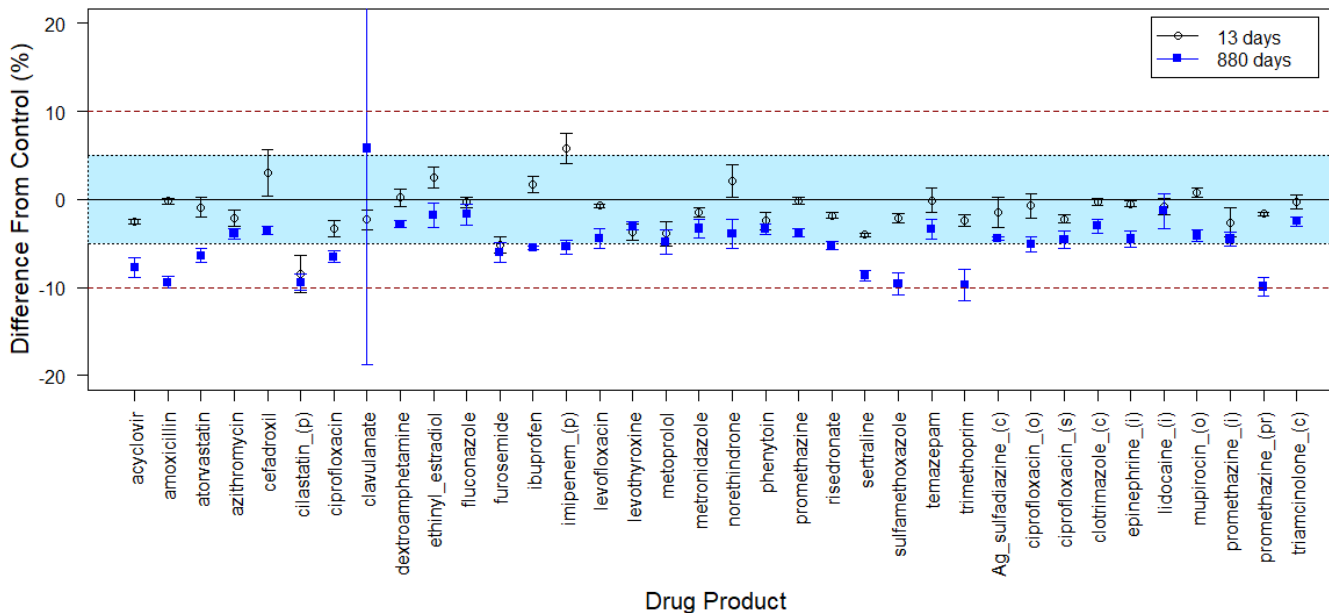
IMPACT = Informing Mission Planning via Analysis of Complex Tradespaces



- **v1.0**
 - Delivery Mar 2023
 - Transition to Operations 2023
 - Operational FY24
- **v1.x**
 - FY24 and following
 - New capabilities and conditions
- **v2.0**
 - Expand from medical to Crew Health and Performance
- Considering options to make IMPACT (results) available external to NASA

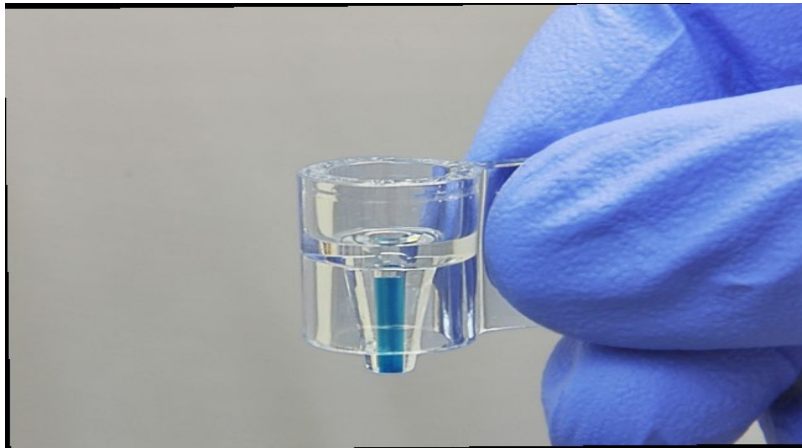
Analysis of the Effect of Spaceflight on Drug Potency to Quantify the Risk of Medication Failure for Exploration Space Missions

- Pre-print of quantitative assessment of medication stability
- New Pharmacokinetics Strategy
- MOU with USAF to analyze additional spaceflight flown pharmaceuticals





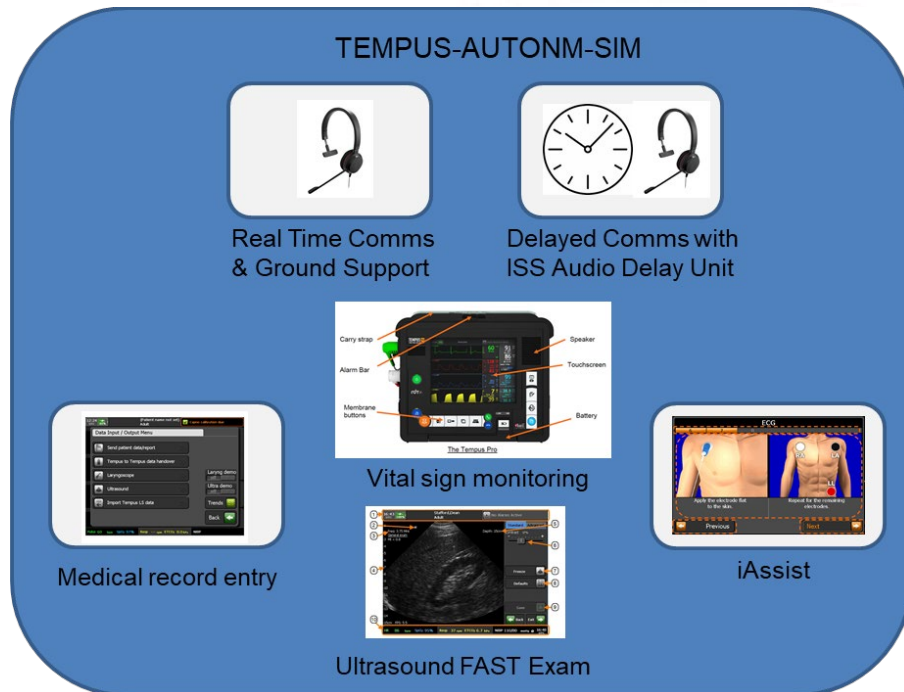
- New Pharm Stability Evidence Report
 - Will be publicly available
- MOU with USAF to analyze additional spaceflight flown pharmaceuticals
- VacuuMed study on Polaris Dawn
 - Stability of meds on exposure to vacuum



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- Point-of-care lab analysis device to monitor clinical and research biomarkers
- Developed with SBIR funds, now COTS technology
- Successful in-flight performance



- Multifunctional medical device
- Collaboration with ESA and XMIPT
- Phase 1
 - Periodic Health Status (PHS) Exam
 - On-orbit contingency drill
- Phase 2
 - Medical contingency simulation
 - Comms: real-time, seconds, minutes
 - Procedural guidance

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Questions?

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